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6. AUTHORS
Drummond, John

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Space and Naval Warfare Systems Center
53560 Hull Street
San Diego, CA 92152-5001

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The application of multimedia transmission has as one of its predominate components network communications. In this paper the author has endeavored to implement and analyze network communication of multimedia information. In this analysis Xpress Transfer Protocol (XTP) and Fiber Distributed Data Interface (FDDI) protocol have been utilized. FDDI is an implementation of the ISO standard for Open Systems Interconnect (OSI) Reference Model Data-Link and Physical layer protocols. These protocol implementations afford us a signaling rate of 100 Mbits/sec in addition to fault tolerance. XTP is an implementation of both the Transport and Network layers within the OSI Reference Model. The basis of this XTP implementation design is that of high performance and efficiency. Employing this protocol, the author has successfully implemented both Unicast and Multicast network communication modes. The results of these implementations are presented in this paper.
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Data Transmission Over Fiber Optics Using High Performance Network Protocol

John Drummond
Space and Naval Warfare Systems Center, San Diego
drummond@spawar.navy.mil

Abstract

The application of multimedia transmission has as one of its predominate components network communications. In this paper I have endeavored to implement and analyze network communication of multimedia information. In this analysis Xpress Transfer Protocol and Fiber Distributed Data Interface protocol have been utilized. This protocol combination has provided a high speed and high performance network solution to the multimedia transmission that requires high bandwidth. FDDI is an implementation of the ISO standard for Open Systems Interconnect (OSI) Reference Model Data-Link and Physical layer protocols. These protocol implementations afford us a signaling rate of 100 Mbits/sec in addition to fault tolerance. XTP is an implementation of both the Transport and Network layers within the OSI Reference Model. The basis of this XTP implementation design is that of high performance and efficiency. Employing this protocol I have successfully implemented both Unicast and Multicast network communication modes. The results of these implementations are presented in this paper.

Introduction

Multimedia (voice, video, data, text, and graphics) distribution over high speed networks has many commercial applications which has revolutionize the way computers and networks are used. Numerous commercial entities have formed strategic alliances to explore new opportunities in this area. I have been experimenting for several years with high speed networks which utilize FDDI, and a high performance network protocol called Xpress Transfer Protocol. I have performed many voice/video transmission experiments using XTP with several machines connected via FDDI network. The results indicate voice and video transmission using XTP and FDDI has many advantages over traditional methods of transmission including fault tolerance, high bandwidth, and data integration.

Xpress Transport Protocol

Xpress Transport Protocol is an implementation of the Open Systems Interconnect (OSI) Reference Model layers 3 and 4, or Network and Transport respectively. XTP allows for extensive application control over the network interface. Within the design of XTP full advantage is taken of the low Bit Error Rate (BER) offered by current network media such as fiber optics. This reduction in error processing allows a shift to the focus of completing other tasks.

XTP notability also includes improvements over other protocols[1]: Data Pipeline Size; Rate Control; Priorities; Out-of-band Data; No-error Mode; Policy Vs Mechanism; Multicast; Header/Trailer Protocol; Fixed-length Fields; Efficient Connection Setup and Teardown; Address Translation Routing; Retransmission; Acknowledged Control; Alignment; and VLSI Implementation When compared to traditional protocols XTP offers various functional enhancements. XTP provides a pipeline design which can accompany megabit and gigabit networks (easily upgraded to terabit). Rate and burst control are accessible via parameters with the rate bits capable of being controlled at the receive side for synchronization purposes. Prioritization provides for user data discrimination. Policy vs mechanism being a primary design philosophy behind XTP allows user level control of implementation instead of fixed pre-established policies, an example of this is the no-error mode setting. Multicast also provides a functional enhancement over common protocols by providing semi-reliability of the network session. Additionally XTP has added features which focus upon performance. The addition of a header/trailer instead of the traditional header in a data packet allows for checksum to be calculated and appended thus reducing one sequential data pass. Fixed-length fields (i.e. header/trailer and flags) provides added efficiency. Connection setup/teardown for reliable transmission requires only two packets (vs TP4 six packets) in addition to providing various connection release paradigm support. XTP addressing translation provides for interoperability of Internet Protocol (IP) and ISO 8348 as well as many other network addressing designs. As XTP has implemented the Network layer protocol it supports routing also

by bridging the Transport/Network layers is has established a "transfer layer" architecture this routing has added efficiency. XTP provides selective retransmission when reliable-service/error-detection mode is desired. Elective acknowledgment control is also provided to the user by XTP.

Recent work within the XTP community is focused upon integration with the IP which resides on the OSI Reference Model Network layer. This number 3 layer provides the necessary routing between network segments. The integration of XTP with IP would greatly enhance XTP's implementation capabilities . Given the numerous IP based routers currently in use around the world this link-up between the two protocols would provide obvious advantages. The utilization of an enhanced Transport layer protocol such as XTP in combination with the popularly employed IP Network layer protocol will allow application specific network communication over Wide Area Network (WAN).

Fiber Distributed Data Interface

The Fiber Distributed Data Interface (FDDI) is an ANSI standard based on timed-token protocol technology. Within the OSI Reference Model FDDI implements a version of Physical and Data Link layers 1&2. A typical network consists of nodes connected by two fiber cables with a logical token circulating among the nodes and a signaling rate of 100 Mbits/sec. The FDDI architecture is to varying degrees fault tolerant. The network topology in our testbed will remain operational if a single fault, such as a cable break, occurs. The FDDI features that are useful in the transmission of voice and video are: High bandwidth (100 Mbit/sec); Very low error rates (10^{-9} BER); Predictable token access (low jitter); Large packet size (4500 bytes). Other characteristics of FDDI that serve practical purposes are: Fault tolerance; No electromagnetic emissions/interference; and Notion of priority.

Testbed Experiments

Our testbed consists of several commercially available Intel based PCs containing off-the-shelf components. Each network node PC is populated with Dual Attached Station FDDI cards, 10-bit resolution audio analog-digital converter cards using Adaptive Differential Pulse Code Modulation (ADPCM) audio compression with 16 kHz sample rate, and 2-card set of video interface boards consisting of JPEG video compression hardware and frame grabber engine which perform the digital video capturing and compression functions. All PCs are connected by a dual ring fiber optic cable.

The experiments follow two basic sequences of operation. The primary operation occurs on the transmitting side of the network communication connection. First task is to obtain video or audio analog data and to perform analog-to-digital conversion. Once completed this digitized information is then compressed using the appropriate data compression algorithm with the respective VLSI chipset (ADPCM for audio and JPEG for video) residing on the hardware. The compressed data is then formed into XTP network packets, by the application and XTP software, for transmission over the Fiber Optic network via the FDDI hardware in the node. The second set of operations is performed at the receiving node, beginning with the receipt by the Fiber Optic network and FDDI hardware in the node. These FDDI frames are processed by XTP and the resulting compressed data is delivered to the appropriate hardware for decompression and the resulting data is output to either the screen in the case of video data or the speaker in the case of audio data. This completes the communication cycle.

Audio Transmission

During the course of our audio experiments latency measurements were taken periodically. This measured latency was indicative of the time required for end to end (i.e. microphone-speaker) transmission. The results indicated a latency of approximately 25ms, which was well within the tolerable limits of perception by the human ear.

One-Way Delay	Effect of delay
>600ms	Incoherent
600ms	Barely Coherent
250ms	Annoying
100ms	Imperceptible (without network/original sample comparison)
50ms	Imperceptible (with network/original sample comparison)

Table 1: ***Effects of latency on human ear perception***[3]

The latency tests were based upon XTP unicast mode communication link sending XTP network packets sized at 50 bytes each, and A/D converter buffered by an array of bytes 1024 long. This schema provided a good basis for testing and analysis. The ADPCM audio compression algorithm compresses the sampled audio waveform to 4 bits thereby reducing the data size by over 50% compared to 10 bit PCM digitization. This compression allows for very low network bandwidth utilization. When operating in unicast mode, the average consumption of network bandwidth given a typical compressed audio packet is .5035 Mbits/sec. XTP unicast mode is a network communication utilizing 2 nodes, where one node acts as a transmitter and another node acts as a receiver. This bandwidth is increased to approximately 1.102 Mbits/sec when utilizing duplex mode communication. XTP duplex mode involves two nodes and each node acts as transmitter and receiver simultaneously.

Video Transmission

The realtime video originated from various sources such as: Cable News Network (CNN) broadcast acquired from satellite downlink; Video Camera; and Video Tape. These sources all followed the NTSC format and all were fed into the video frame grabber. Again, during our experiments, latency measurements were recorded periodically. This time the measured latency was representative of the time required for picture to picture (i.e. screen display to screen display) transmission. The outcome of these tests revealed a latency of approximately 50-60ms (less than 2 frames) given that our experiments were based upon utilizing NTSC standard input which is 30 fps. This small latency is very difficult to perceive, even with the source and destination display screens side by side. Table 2 represents some results of a study [3] on frame rates and their effects on human eyes. As can be seen, a jerky motion is perceived when successive frames are 67-83 ms apart. This is in excess of the latency in our experiment between a frame appearing on the source screen and the same frame appearing on the destination screen.

Frames per second	Effect on human eye
<10 fps	Frames appear disjoint
12-15 fps	Motion is jerky.
30 fps	Television quality
60-75 fps	High-motion discernible (HDTV)
90 fps	Limit of human eye perception

Table 2: ***Effects of frame rate on human eye perception*[3]**

These latency tests were also based upon XTP unicast mode communication link with XTP network packets sized at 3305 bytes each, and a video buffer of 16000 bytes. The JPEG video compression chipset utilizing the Huffman encoding scheme provided us with 2 to 4 times data reduction thus greatly reducing the network bandwidth requirements for our realtime video communication experiments. A typical XTP unicast communication session utilized approximately 3 Mbits/sec to 6 Mbits/sec bandwidth. The XTP multicast sessions were recorded to also within the 3 Mbits/sec to 6 Mbits/sec range of network bandwidth consumption.

Conclusion

After performing the audio and video experiments in our testbed, the results have indicated the use of XTP and FDDI on multimedia transmission is feasible and may provide a bridge to the giga-bit network rates. The results of the XTP multicast bandwidth consumption is revealing in that it is within the range of the typical XTP unicast network utilization despite the fact that unicast is a 1 to 1 session and multicast is 1 to N network communication As multimedia is becoming an important industry today, more research in multimedia transmission is needed.

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